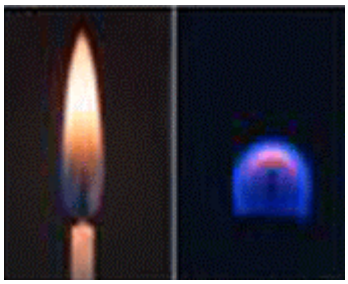
Fire Prevention In Space

What are the basic fire response techniques every child learns? Stop, Drop, and Roll; Plan an escape route with an outside meeting place; Dial 911 for help. These survival tips don't apply to astronauts on the International Space Station (ISS). They have different conditions in space and different responses if a fire should break out. Fires in space are a bit different from fires on Earth, but just like on the ground, the best way to fight a fire is to prevent it from starting.

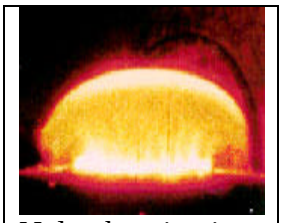


In low gravity situations, there is no buoyancy from flames, says Gary A. Ruff, aerospace engineer at Glenn Research Center's Microgravity Combustion Science Branch. "Buoyancy is what makes a flame long and pointed here on Earth," Ruff says. "As the hot gases from a flame begin to rise, they create air currents that bring fresh air to the fire. In microgravity, there is no buoyancy, so instead of a tall yellow flame on a candle, for example, you'll see a smaller, blue flame centered on the wick. Convection—the movement of air—is one of the important ways heat is transferred to other spaces. Without that, fires don't spread as rapidly.

There's a complication to that scenario, however, says Ruff. "Because astronauts need fresh air to breathe, there is a lot of ventilation coming from low-velocity fans on the Space Station. This replaces natural convection, so fires do indeed spread in space—but because the ventilation system can supply the air the fire needs to burn, it can spread in any direction, rather than just up." It's not just the direction of flame spread that can be different in space, though. Because the shape of the flame is different, flames can produce different amounts of soot, smoke, or harmful gases than their counterparts in normal gravity. "Combustion in microgravity is a very difficult problem, and there are a lot of engineers and scientists working to understand it better," Ruff says.

Protection, Detection, and Response

All materials going up into space are tested for flammability here on Earth. They are placed in a special test chamber and ignited with a hot wire. If the flame spreads, then the material is flammable. Some items are so important to a mission's success that they're permitted to travel to space, despite being flammable. Items of clothing, fuels, experiments, and paper products may not be fireproof, but with the proper precautions, they can still make the trip to space with a waiver and specific instructions for storage, placement, and disposal.


Nylon burning in microgravity

Detecting a fire in space is also different. On Earth, smoke detectors are installed on the ceiling or upper section of a wall because that's the direction smoke travels. In space, smoke doesn't rise, so detectors on ISS are placed within the ventilation system to detect smoke in the air supply.

Russian modules on ISS use a water-based foam fire extinguisher, while the other modules feature carbon dioxide (CO_2) units. There's an advantage to having two styles of extinguisher on board, Ruff says. Some fires respond better to foam than CO_2, while in other situations, the opposite is true. With both methods available, any fire that arises could be contained more easily.

While the ISS hasn't experienced a fire, a significant one did take place in 1997 on the Russian Space Station *Mir*. "The *Mir* fire came from an oxygen generator, where the oxygen supplied a ready source of fuel," says Ruff. "Extinguishers probably didn't help that situation. Tests run later back on Earth showed that the generator had to run out of oxygen for the fire to burn out." There are similar oxygen generators on the ISS, but using lessons learned from *Mir*, they're redesigned with a special screen to prevent overheating.

Easy as 1-2-3

If a fire would ever occur on the ISS, the astronauts would become firemen and follow a three-step response system.

1. Turn off the ventilation system to slow the spread of fire. Removing the air current decreases the amount of oxygen available to the flame. Turning off the ventilator also reduces transporting smoke to other areas in the Space Station. After all, astronauts can't open a window for fresh air!
2. Shut off power to the affected unit. If it were an electrical fire, the astronauts wouldn't want other systems to be exposed to possible shorting or overheating.
3. Use fire extinguishers. Experiment racks, which are closed units, have ports where a fire extinguisher's nozzle can be inserted and the flow of extinguishing agent directed to the fire.

CO_2 fire extinguisher used on ISS

Ruff says that while there hasn't been a fire on the Space Station, and while safeguards have been in place to prevent one from occurring, it's comforting to know that astronauts could respond to an emergency because they've prepared for any eventuality.

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